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Vsystem TO EPICS CONTROL SYSTEM TRANSITION AT THE ISIS ACCELERATORS

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Abstract

The ISIS Neutron and Muon Source at Rutherford Appleton Laboratory is a pulsed source used for research in material and life sciences. A linac and synchrotron accelerate protons to produce neutrons in two spallation targets. The accelerators are currently operated using commercial Vsystem control software. A transition to the EPICS control system is underway, with the end goal of a containerised system preferring the pvAccess protocol. We report the progress of this transition, which is being done without disrupting ISIS operations. We describe a bidirectional interface between Vsystem and EPICS that enables the two control systems to co-exist and interact. This allows us to decouple the transition of controls UI from the associated hardware. Automated conversion of the binary-format Vsystem control screens has been developed that replicates the current interface in EPICS, allowing minimal retraining of operators. We also outline the development of EPICS interfaces to standard and unique-to-ISIS hardware, reuse of and managing continuity of existing long-term data archiving, the development of EPICS interfaces to standard and unique-to-ISIS hardware, and migration of alerts.

INTRODUCTION

The accelerators at the ISIS Neutron and Muon Source [1, 2] at Rutherford Appleton Laboratory currently operates using Vsystem [3] commercial control system software. A transition to the open source EPICS control system [4] is in progress. (Note that ISIS Experiment Controls has already transitioned to the use of EPICS [5].) One of the requirements of this transition is that operations must not be interrupted. For this reason the two control systems will be run in parallel during the transition.

There are a variety of different ways to configure an EPICS control system and so a number of high-level decisions had to be made before beginning the transition work. Some of the decisions driving the ISIS accelerator controls transition are:

- to prefer pvAccess [6] over Channel Access
- to prefer IOCs (or equivalents) in containers on centrally managed servers
- to deploy Phoebus [7] for user interaction

Other decisions have been deferred, these include:

- selection of technology for long-term archiving of PVs
- selection of alarm handler software

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PVECHO - VSYSTEM/EPICS BRIDGE

To allow the simultaneous use of Vsystem and EPICS during the transition period software called PVEcho [8] has been developed to act as a bridge between the two control systems. PVEcho allows changes in the channels or process variables (PVs) of one control software system to be reflected immediately in the other. PVEcho is divided into two parts – v2e and e2v – depending on whether the underlying hardware interface is managed by Vsystem or EPICS respectively. In light of the decision to prefer pvAccess, PVEcho only fully supports this EPICS protocol.

If the hardware interface is managed by Vsystem then v2e creates a set of EPICS process variables which mimic the Vsystem channels, reflecting the changes in those channels and if modified via EPICS propagating the change to Vsystem. This allows Phoebus screens to be deployed to control and monitor hardware for which Vsystem interfaces exist without needing to move the associated hardware interfaces immediately to EPICS IOCs.

If the hardware interface is managed by EPICS then e2v similarly acts as a bridge to propagate values to Vsystem channels and to propagate any changes to those Vsystem channels back to the matching EPICS PV. Thus hardware interfaces may be moved to EPICS without requiring all associated Vsystem control screens or scripts to be ported at the same time.

This approach allows the two major areas of the transition work – transition of hardware interfaces and transition of control screens (and scripts) – to be decoupled.

CONVERSION OF CONTROL SCREENS

ISIS operations are managed from a Main Control Room (MCR) which is staffed at all times. The MCR crew are the principal users of the control system, using the alarm system and control screens to interact with hardware across the accelerators and targets. The control screens are also used by machine physicists during setup of ISIS before a user run, tuning of the machine during the run, and for studies of the properties of the machine. Equipment owners access the control screens during commissioning of their equipment and for routine inspection and monitoring during operation.

There are more than 800 Vsystem control screens accessible through the ISIS control system. Transitioning these screens to Phoebus represents a very significant conversion effort. The initial plan was for this to be done manually by contractors. However, a technical alternative was developed.

The Vsystem control screens are created and run by Vdraw [9] and are stored in binary encoded files. Software writ-

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ten in Python was developed to automatically convert these to the XML data format used for Phoebus control screens. The automatic conversion is not perfect so most converted screens needs to be manually edited.

In Fig. 1 we show the results of the automatic conversion of a complex screen. Fig. 1(a) shows the original Vsystem screen and (b) the screen after automatic conversion. Some manual editing is still required; (c) shows the final Phoebus screen after this has been done. The data displayed is provided by the v2e component of PVEcho, demonstrating decoupling of the transition of control screens from that of the hardware interfaces.

(a)

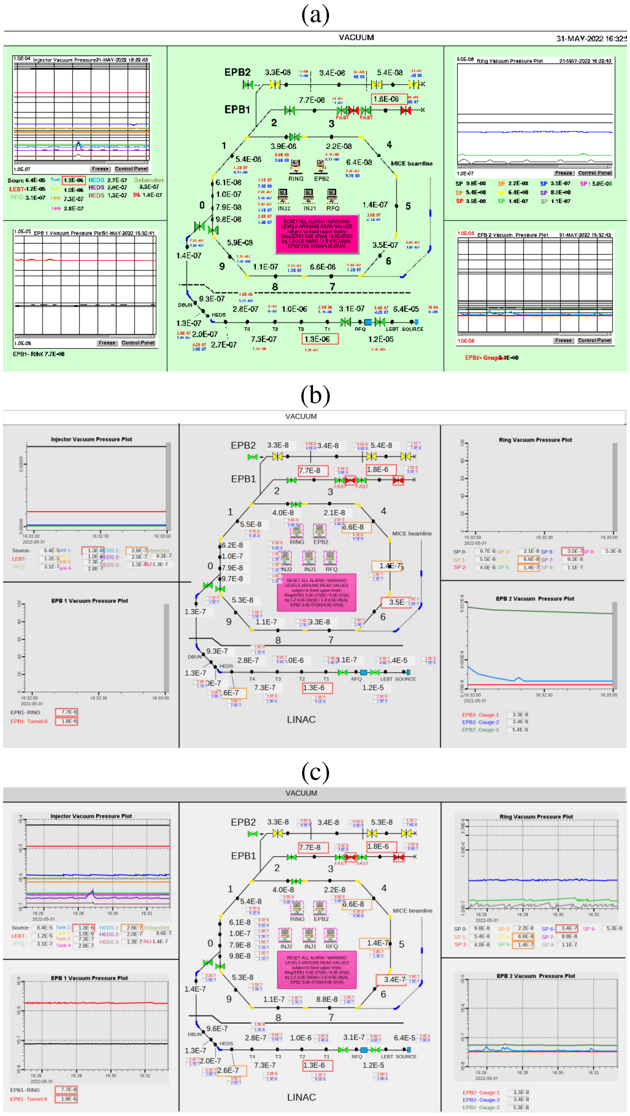

Figure 1: (a) Original Vsystem screen, (b) screen converted to Phoebus by VCDparser, (c) converted screen after manual corrections.

The screen shown in Fig. 1 displays vacuum levels and their histories for the ISIS Synchrotron. The manually-corrected Phoebus screen (c) has been run for more than a full user cycle in the ISIS MCR, in parallel with the Vsystem screen (a). This is intended to allow feedback from the crew and demonstrate reliability of the entire technology stack before further automatically converted screens are deployed.

The conversion software is still under development and it is necessary to rerun the automatic conversion to capture improvements to the converted screens. In a simple conversion this overwrites any manual adjustments made to the converted screen. For this reason we are currently testing a smarter automatic conversion which preserves previous manual edits.

Work is also underway on developing standards for Phoebus UI components and colours.

SUPPORT FOR ISIS-SPECIFIC IOCS

Common Industrial Protocol

ISIS Target Station 1 (TS1) has run for over 35 years without significant structural improvement. During the planned long shutdown of 2021–22 a large scale upgrade of TS1 [10] began, with commissioning planned for September 2022. As part of this upgrade the existing control systems hardware has been replaced with newer Omron PLCs. ISIS Targets have previously interfaced with Vsystem over the FINS protocol, but this is considered obsolescent and will be replaced with the CIP protocol [11].

No hardware interface between Vsystem and CIP has been previously developed. A decision was taken not to develop such an interface and instead to control the new hardware through EPICS.

There are two unusual requirements for this new EPICS interface. The first is that some PVs have complex time-based hysteresis requirements to trigger alarms, and the second was that alarm threshold values and associated alarm messages be controlled from the PLCs (single source of truth). To meet these requirements a CIP data structure which encapsulated all the required data was agreed. An array of these structures would be read from the PLCs. Python code using the PvaPy [12] and cpppo [13] libraries was developed to read this array of structures and convert it into a set of EPICS PVs.

Unfortunately in testing it was determined that the reading of the array was too slow. Even after optimisation it took over 15 seconds to read a large array of the agreed structures. This was due to the combination of the maximum data window size (~2000 bytes) and other issues with the purchased NJ101 PLCs. For this reason the agreed system had to be revised and two parallel arrays for the value and the alarm state of the PVs created. It is possible to read these smaller arrays of numbers in less than 0.5 seconds, while a parallel loop reads the array of full structures more slowly.

CPS, PXI and Other Interfaces

The majority of Vsystem channels at ISIS interface with CPS crates [14], custom hardware based on a CompactPCI backplane. An XML web service running on the crates is used to read and write data. The same XML system is used to interface with code running on a smaller number of National Instruments PXI crates.

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An EPICS interface using PvaPy was developed and tested to interface with the CPS and PXI systems. It is now planned to replace this custom solution with a more conventional IOC using the asyn module. In the future these systems may become an exception to our preference for server deployed IOCs and run their own IOCs directly.

Conventional EPICS IOCs running in Docker using the FINS and Modbus protocols have also had test deployments.

ARCHIVING CONTROLS DATA

Vsystem has built-in logging functionality called Vlogger [9]. However, at ISIS the primary tool for logging controls data is InfluxDB which collects data from Vsystem via the MQTT message protocol and Telegraf metrics collection agent [15]. The data is visualised using Grafana dashboards.

The EPICS Archiver Appliance [16] has been deployed at ISIS and is logging data from the CIP PLCs described above. At this early stage in the transition most of our controls data still originates with Vsystem and is stored in InfluxDB. For any cross-analysis it is useful to have all data within one system, and tools have therefore been developed to allow EPICS data to be stored in our existing InfluxDB system. When PVEcho's e2v component is properly configured it passes data through Vsystem which is automatically logged by our existing infrastructure. In addition, software named pvxs-archiver [15] has been developed which can directly write monitored EPICS PVs to InfluxDB.

We plan to evaluate the EPICS Archiver Appliance against InfluxDB. One of the principal advantages of the EPICS Archiver Appliance is its integration with Phoebus. However, it may be possible to develop an interface for InfluxDB which implements the same web API which allows Phoebus to access data from the EPICS Archiver Appliance. It remains to be determined if this is an optimal use of developer effort.

ALARMS

Alarm display and acknowledgement at ISIS is currently primarily handled by the Valarm [9] component of Vsystem. Because of the operational importance of correctly displaying alarms it is anticipated that this will be one of the last components transitioned to EPICS.

However, as described the new TS1 PLCs will use EPICS and some of those PVs will need to trigger alarms in the MCR. The e2v component of PVEcho will be used to bridge the alarmed PVs to Vsystem channels, and be responsible for setting the correct alarm state.

In the longer-term as the transition continues the ISIS MCR will switch to an EPICS alarm handler, and PVEcho will be responsible for ensuring the legacy Vsystem alarms are visible to it. This handler has not yet been selected.

CONCLUSION

EPICS Phoebus screens are being tested in the ISIS MCR, enabled by automated conversion of control screens and the PVEcho bridge to the existing Vsystem control system. With the commissioning of TS1, testing will begin of end-to-end EPICS (from hardware interfaces to display in the MCR with alarms and long-term archiving). We expect rapid progress in transitioning control screens and hardware interfaces to EPICS in the near-term.

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